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Original Paper
Bryophyte flora of the Apodi Plateau, Ceará, Brazil

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Abstract

In the state of Ceará, bryophytes have been mainly sampled in humid and sub-humid enclaves, remnants of Atlantic rain forest, while studies in the Caatinga Domain are practically non-existent. The present work aimed to survey the floristic composition of bryophytes of the Apodi Plateau, a region predominantly covered by Caatinga. Collections were conducted as part of the field activities of the Program for Research in the Biodiversity of the Semiarid region of Brazil (PPBio). The briological material was collected in 2014, in the Apodi Plateau located within the territory of Ceará state. Fifty-nine bryophyte species were found: 27 liverworts - Marchantiophyta - distributed in seven families and 11 genera, and 32 mosses - Bryophyta - distributed in 14 families and 26 genera. Among the species found, 25 were new records for the state of Ceará and *Riccia subplana* is reported for the first time for the Northeast region of Brazil. Twenty-three are new records for the Caatinga Domain. Taxonomic comments are provided for the new records for the state of Ceará and for Caatinga, as well as an illustration of the species *Weisiopsis bahiensis*.

Key words: Bryophyta, Marchantiophyta, taxonomy.

Resumo

No estado do Ceará, as principais áreas amostradas com relação às briófitas são constituídas de encraves úmidos e subúmidos, remanescentes da Mata Atlântica. Estudos em áreas de Caatinga são praticamente inexistentes. O presente trabalho objetivou realizar um inventário florístico das briófitas da Chapada do Apodi, dentro dos limites do território do estado do Ceará, uma região com predominância do Domínio Caatinga. As coletas fizeram parte das atividades de campo do Programa de Pesquisa em Biodiversidade do Semiárido (PPBio). O material briológico foi coletado em 2014, na área da Chapada do Apodi localizada dentro do território do estado do Ceará. Foram encontradas 59 espécies de briófitas sendo 27 hepáticas - Marchantiophyta - distribuídas em sete famílias e 11 gêneros e 32 espécies de musgos - Bryophyta - distribuídas em 14 famílias e 26 gêneros. Das espécies encontradas, 25 se configuram como novos registros para o estado do Ceará e *Riccia subplana* está sendo citada pela primeira vez para a Região Nordeste. Estão sendo acrescentados ainda 23 novas ocorrências para a Caatinga. São fornecidos comentários taxonômicos para as novas ocorrências para o estado do Ceará e para a Caatinga. A espécie *Weisiopsis bahiensis* é ilustrada.

Palavras-chave: Bryophyta, Marchantiophyta, taxonomia.

Introduction

The northeastern region of Brazil occupies an area of 1,540,827 km^2 (Nimer 1989), and has a semiarid climate in approximately 800,000 km^2, corresponding to 10% of the Brazilian territory (Ab'Sáber 1974). The relief has altitudes mostly below 500 m, among surfaces that reach 1,000 m in the Borborema, Araripe and Ibiapaba plateaus, up to 1,200 m in the Diamantina plateau. This altitudinal variation associated with the position in the relief, where the increasing altitude causes forced convective rains and lower temperatures, leads to the occurrence of different types of vegetation. The xerophilous Caatinga vegetation is dominant in the semiarid area, presenting physiognomic and floristic variations (Romariz

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1974; Ferri 1980; Andrade-Lima 1981; Sampaio 1995; Rizzini 1997).

The different physiognomies of the Caatinga hold a diversified biological heritage, with rare and endemic taxa (Giulietti *et al.* 2004) and an invaluable richness of plant and animal species (MMA 2004). In contrast to other semiarid regions of the world, the biological diversity of the Caatinga is extremely significant (Luetzelburg 1974; Andrade-Lima 1981; Araújo Filho & Carvalho 1997) and adds biological and economic value to Brazil. Despite such remarkable characteristics, the Caatinga is one of the least known domains in the country. This situation is a consequence of the belief that the Domain has a very low diversity, no endemic species, and vegetation that is strongly modified by anthropic actions (Giulietti *et al.* 2004). It is noteworthy that this vegetation is one of the most affected by human interference in Brazil; in 2008, approximately 45% of its original coverage had already been deforested (MMA 2010). According to Castelletti *et al*. (2004), the last intact native vegetation remnants are extremely fragmented.

The Northeast region of Brazil ranks third in number of bryophyte species, behind the South and Southeast regions (Costa & Peralta 2015). As for the bryophyte flora of the state of Ceará, this is still partially known. Most studies on the flora of Ceará have focused on flowering plants, for they represent the predominant vegetation. There are still few reports of bryophytes in Ceará, especially due to the lack of collections in native vegetation, although bryophytes can be found even in the most inhospitable places (Brito & Pôrto 2000). The best explored areas to date are quite small and, considering the extension of the state, it is unlikely that the results obtained portray the real situation of the bryophyte flora of Ceará. The main areas sampled until present are humid and sub-humid enclaves, remnants of Atlantic rain forest (Oliveira & Alves 2007; Oliveira & Bastos 2009, 2010a, b; Siqueira *et al.* 2011).

There are no works specifically addressing the bryophytes growing in the Caatinga in Ceará. The few studies carried out so far were floristic surveys in humid environments, in high altitudes such as the Ibiapaba Plateau (Oliveira & Bastos 2009, 2010a,b) and the Guaramiranga mountain (Yano & Pôrto 2006). In this context, the Apodi Plateau, located in the eastern side of Ceará, represents a relevant area to the study of bryophytes growing in the Caatinga, taking into account the lack of works in the region. The knowledge of the bryophyte flora of the Apodi Plateau is fundamental to understand the diversity of the ecosystem as a whole, aiming at environmental valuation and support to appropriate management measures.

The present study aimed to carry out a floristic survey of the bryophytes of the Apodi Plateau, within the limits of the territory of the state of Ceará.

Material and Methods

Study area

The Apodi Plateau is located in the eastern side of the state of Ceará, also extending into the territory of Rio Grande do Norte (Fig. 1). In general, the natural vegetation is represented by hyperoxerophilic Caatinga, which is part of the dominant landscape of the ecosystem of the Apodi Plateau, associated to secondary forests with varied herbaceous strata. According to Filho *et al.* (2001), different types of vegetation coverage can be observed in the region: Savanna (Cerrado); Forested savanna (Cerradão), currently named as xeromorphic tropical subcaducifolia forest; Carrasco; and a seasonal dense Ombrophilous Forest remnant, probably resulting from great environmental heterogeneity throughout many geological periods (Giulietti *et al.* 2004). Fernandes (1990) believes that the presence of a forest such as Cerradão in the state of Ceará was driven by climate change through geological time, which also caused progressions and regressions of this forest into the central region of Brazil. The predominant climate of the region is Hot Sub-humid Tropical, the soil is Yellow Dystrophic Latosol, and the mean annual precipitation and temperature is 1,061 mm and 25 °C, respectively.

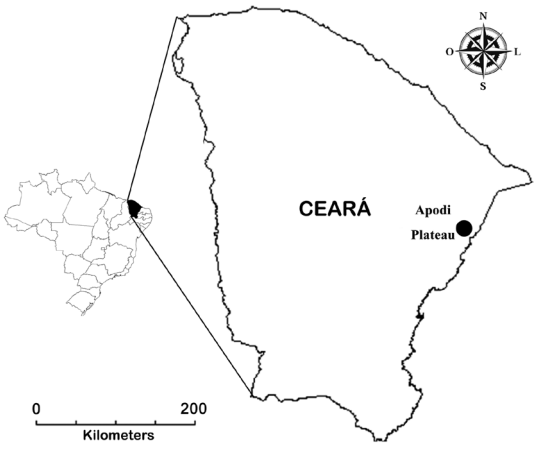

Figure 1 – Location of the Apodi Plateau.

Collections of botanical material

Collections were part of the field activities of the Program for Research in the Biodiversity of the Semiarid region of Brazil (PPBio). Briological material was collected in 2014, in the Apodi Plateau located within the territory of Ceará, according to specialized techniques described in Frahm (2003). The material was collected manually or with the aid of a knife and stored in Kraft paper bags. In the field, altitudes and geographical coordinates were recorded at all points of collection with the aid of a GPS. The following data were also recorded: date and site of collection, type of ecosystem, habit, growth form, colonized substrate (bryocenological group), and other relevant ecological and/or taxonomic observations.

Samples were identified in the Plant Taxonomy Laboratory of the Universidade Estadual de Feira de Santana. For the macro and microscopic analysis, morpho-anatomical characteristics of gametophytes and sporophytes were observed with the aid of a stereomicroscope and an optical microscope. The classification system used was the one of Crandall-Stotler *et al.* (2009) for liverworts, and Goffinet *et al.* (2009) for mosses. The geographical distribution of the species in Brazil was based on the BFG (2018). In order to identify species, the following works were used: Buck (1998), Bordin & Yano (2013), Costa (2016), Frahm (1991), Gradstein & Costa (2003), Lemos-Michel (2001), Sharp *et al.* (1994), Yano & Peralta (2007) and Zander (1993).

Vouchers of the identified material were deposited in the collection of the Herbarium of the Universidade Estadual de Feira de Santana (HUEFS).

Results

Fifty-nine bryophyte species were recorded, consisting of 27 liverworts - Marchantiophyta - distributed in seven families and 11 genera, and 32 mosses - Bryophyta - distributed in 14 families and 26 genera (Tab. 1). Among the species found, 25 are new records for Ceará, and *Riccia subplana* Steph. is reported for the first time to the Northeast region of Brazil. Twenty-one are new occurrences for the Caatinga Domain.

The predominant community, regarding the colonized substrate, was the corticolous (32 spp.), followed by rupicolous (12 spp.), terrestrial (10 spp.) and epixylous (6 spp.).

A list of all the new records for the state of Ceará, for the Caatinga, and for the Northeast region, with taxonomic comments for each species, is provided in the list below, in alphabetical order of families. An illustration of *Weisiopsis bahiensis* (Müll. Hal.) Broth. is provided because this is a species with restricted distribution in Brazil, cited only for the states of Bahia (site where the type was collected) and Piauí, and because there are few illustrations of the species available in the literature.

Marchantiophyta

Cephaloziellaceae Douin

Cylindrocolea rhizantha (Mont.) R.M.Schust., New Hedwigia 22 (1-2): 175. 1971 [1972].
The illustrations of this species is in Gradstein & Costa (2003).

It is characterized by bilobed leaves with acute to obtuse apex and subquadratic cells. It resembles *Cylidrocolea planifolia*, but presents relatively larger gametophytes (0.5–1 mm long). It was found on live bark. It is a new record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC), Northeast (BA, PE), Midwest (GO), Southeast (ES, RJ, SP).

Lejeuneaceae Cavers

Archilejeunea fuscescens (Hampe ex Lehm.) Fulford, The Bryologist 45: 174. 1942.
The illustrations of this species is in Gradstein & Costa (2003).

It is characterized by creeping habit, green to brown coloration, entire and imbricate underleaves, oblong-orbicular leaves with rectangular lobules, which have an apical tooth consisting of 1–2 cells. It was collected on rotting log. It is one of the most common epiphytic liverworts in the Amazon forest and is reported here for the first time for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC, AM, PA, RR), Northeast (AL, BA, PE), Southeast (ES, MG, RJ).

Ceratolejeunea cornuta (Lindenb.) Steph., Pflanzenw. Ost-Afrikas C: 65, 1895.
The illustrations of this species is in Dauphin (2003).

It is distinguished by inflated, spherical lobules present in some parts or in the whole plant, and perianths with four horns. It was found on live bark. This is the first record for the Caatinga Domain. Brazilian geographical distribution:

Table 1 – Bryophyte species found in the Apodi Plateau, Ceará, Brazil. Substrates (Sub.): CO = corticolous; EX = epixylous; EF = epiphyllous; RU = rupicolous; TE = terrestrial. Domains: AM = Amazon; AT = Atlantic rain forest; SA = Savannah; CA = Caatinga; PA = Pampa; PL = Pantanal. The number of genera and species is given inside parentheses, next to each family name. ¨ = new record for the Caatinga Domain; * = new record for the state of Ceará; ** = new record for the Northeast of Brazil.

Taxa	Sub.	Domains	World Distribution	Vouchers
Marchantiophyta				
Cephaloziellaceae Douin (1/1)				
¨**Cylindrocolea rhizantha* (Mont.) R.M.Schust.	CO	AM, AT, SA	Neotropical	Reis TR 410
Corsiniaceae Engl. (1/1)				
Cronisia weddellii (Mont.) Grolle	TE	AT, CA, SA	Endemic to Brazil	Reis TR 357
Frullaniaceae Lorch. (1/3)				
Frullania caulisequa (Nees) Nees	RU	AM, AT, CA, SA, PA	Neotropical	Reis TR 404
Frullania ericoides (Nees) Mont.	CO	AM, AT, CA, SA, PA, PL	Neotropical	Reis TR 375
Frullania kunzei (Lehm. & Lindenb.) Lehm. & Lindenb.	RU	AM, AT, CA, SA, PL	Neotropical	Reis TR 404
Lejeuneaceae Cas.-Gil (5/12)				
¨**Archilejeunea fuscescens* (Hampe *ex* Lehm.) Fulford	EX	AM, AT	Neotropical	Reis TR 396
¨*Ceratolejeunea cornuta* (Lindenb.) Steph.	CO	AM, AT	Neotropical	Reis TR 399
¨**Ceratolejeunea laetefusca* (Austin) R.M.Schust.	CO	AM, AT, SA	Neotropical	Reis TR 381
¨**Cheilolejeunea acutangula* (Nees) Grolle	EX	AM, AT, SA	Neotropical	Reis TR 402
¨**Cheilolejeunea adnata* (Kunze *ex* Lehm.) Grolle	CO	AM, AT, SA	Neotropical	Reis TR 385
¨**Cheilolejeunea discoidea* (Lehm. & Lindenb.) R.M.Schust. & Kachroo	CO	AT, SA, PL	Neotropical	Reis TR 381
Cheilolejeunea rigidula (Mont.) R.M.Schust.	CO	AM, AT, CA, SA, PL	Pantropical	Reis TR 390
¨*Cheilolejeunea xanthocarpa* (Lehm. & Lindenb.) Malombe	EX	AT, SA	Pantropical	Reis TR 402
¨**Lejeunea aphanes* Spruce	CO	AT, PL	Neotropical	Reis TR 381
Lejeunea flava (Sw.) Nees	RU	AM, AT, CA, SA, PA, PL	Pantropical	Reis TR 404
Lejeunea laetevirens Nees & Mont.	CO	AM, AT, CA, SA, PL	Neotropical	Reis TR 387
¨**Lejeunea oligoclada* Spruce	CO	AT	Endemic to Brazil	Reis TR 410
Marchesinia brachiata (Sw.) Schiffn.	CO	AM, AT, CA, SA	Neotropical	Reis TR 410
Metzgeriaceae Raddi (1/2)				
¨*Metzgeria albinea* Spruce	CO	AT, SA	Neotropical	Reis TR 400
Metzgeria furcata (L.) Dumort.	CO	AM, AT, CA, SA	Neotropical	Reis TR 410

Taxa	Sub.	Domains	World Distribution	Vouchers
Plagiochilaceae (Joerg.) K. Müll. (1/4)				
¨***Plagiochila cristata* (Sw.) Lindenb.	CO	AM, AT	Neotropical	Reis TR 400
Plagiochila disticha (Lehm. & Lindenb.) Lindenb.	CO	AM, AT, CA, SA, PL	Neotropical	Reis TR 392
Plagiochila martiana (Nees) Lindenb.	CO	AM, AT, CA, SA, PA	Neotropical	Reis TR 410
¨***Plagiochila patula* (Sw.) Lindenb.	CO	AM, AT	Neotropical	Reis TR 381
Ricciaceae L. (1/3)				
**Riccia albopunctata* Jovet-Ast	TE	AT, CA, SA, PL	Neotropical	Reis TR 347
¨***Riccia subplana* Steph.	TE	AM, PA	Neotropical	Reis TR 314
Riccia vitalii Jovet-Ast	TE	AM, AT, CA, SA, PA, PL	Neotropical	Reis TR 294
Bryophyta				
Brachytheciaceae Schimp. (2/3)				
Squamidium leucotrichum (Taylor) Broth.	EX	AM, AT, CA, SA	Neotropical	Reis TR 402
Squamidium nigricans (Hook.) Broth.	EX	AT, CA	Neotropical	Reis TR 402
Zelometeorium patulum (Hedw.) Manuel	CO	AM, AT, CA, SA, PL	Neotropical	Reis TR 410
Bryaceae Schwägr. (3/4)				
**Brachymenium exile* (Dozy & Molk.) Bosch & Sande Lac.	TE	AT, CA, SA	Endemic to Brazil	Reis TR 361
Bryum argenteum Broth.	RU	AM, AT, CA, SA, PA	Pantropical	Reis TR 404
Bryum coronatum Schwägr.	TE	AT, CA	Pantropical	Reis TR 342
¨**Rosulabryum densifolium* (Brid.) Ochyra	TE	AT, SA	Neotropical	Reis TR 409
Calymperaceae Kindb. (3/3)				
Calymperes palisotii Schwägr.	CO	AM, AT, CA, SA	Neotropical	Reis TR 381
Octoblepharum albidum Hedw.	CO	AM, AT, CA, SA, PA, PL	Pantropical	Reis TR 399
¨**Syrrhopodon parasiticus* (Sw. *ex* Brid.) Besch.	CO	AM, AT, SA, PL	Pantropical	Reis TR 398
Cryphaeaceae Schimp. (1/1)				
Schoenobryum concavifolium (Griff.) Gangulee	CO	AM, AT, CA, PA, PL, SA	Neotropical	Reis TR 400
Fabroniaceae Schimp. (1/1)				
Fabronia ciliaris (Brid.) Brid.	CO	AM, AT, CA, PL	Bolivia, Chile, Ecuador and USA	Reis TR 387
Fissidentaceae Schimp. (1/2)				

Taxa	Sub.	Domains	World Distribution	Vouchers
Fissidens anguste-limbatus Mitt.	TE	AM, AT, CA, SA, PA, PL	Neotropical	Reis TR 363
Fissidens hornschuchii Mont.	TE	AM, AT, CA, SA, PA, PL	Neotropical	Reis TR 338
¨**Fissidens perfalcatus* Broth.	CO	AT, SA	Neotropical	Reis TR 381
Leucobryaceae Schimp. (1/2)				
Campylopus pilifer Brid.	RU	AM, AT, CA, SA, PA	Neotropical	Reis TR 404
Campylopus savannarum (Müll. Hal.) Mitt.	EX	AM, AT, CA, SA, PL	Pantropical	Reis TR 402
Meteoriaceae Kindb. (2/2)				
Floribundaria flaccida (Mitt.) Broth.	CO	AM, AT, CA, SA, PL	Neotropical	Reis TR 406
¨**Meteorium nigrescens* (Sw. *ex* Hedw.) Dozy & Molk.	CO	AM, AT, SA, PL	Neotropical and Africa	Reis TR 406
Orthotrichaceae Arn. (2/2)				
¨**Groutiella tomentosa* (Hornsch.) Wijk & Margad.	CO	AM, AT, SA	Pantropical	Reis TR 387
¨**Schlotheimia jamesonii* (Arn.) Brid.	RU	AM, AT, SA, PA	Neotropical	Reis TR 395
Pottiaceae Schimp. (4/4)				
**Barbula indica* (Hook.) Spreng.	RU	AM, AT, CA, SA, PL	Pantropical	Reis TR 310
Dolotortula mniifolia (Sull.) R.H. Zander	TE	AT, CA, SA	Neotropical	Reis TR 311
Hyophilla involuta (Hook.) A. Jaeger	RU	AM, AT, CA, SA, PA, PL	Neotropical	Reis TR 312
¨**Weisiopsis bahiensis* (Müll. Hal.) Broth.	RU	SA	Endemic to Brazil	Reis TR 309
Pterobryaceae Kindb. (1/2)				
Orthostichopsis praetermissa W.R. Buck	CO	AM, AT, CA, SA	Neotropical	Reis TR 406
Orthostichopsis tortipilis (Müll. Hal.) Broth.	RU	AM, AT, CA	Neotropical	Reis TR 401
Pylaisiadelphaceae Goffinet & W.R. Buck (1/1)				
Isopterygium tenerum (Sw.) Mitt.	CO	AM, AT, CA, SA, PA, PL	Cosmopolitan	Reis TR 394
Sematophyllaceae Broth. (1/2)				
**Sematophyllum adnatum* (Michx.) Brid.	CO	AM, AT, CA, SA, PA, PL	Neotropical and Africa	Reis TR 385
Sematophyllum subpinnatum (Brid.) E. Britton	CO	AM, AT, CA, SA, PA, PL	Pantropical	Reis TR 398
Stereophyllaceae W.R. Buck & Ireland (2/3)				
Entodontopsis leucostega (Brid.) W.R. Buck & Ireland	RU	AM, AT, CA, SA, PL	Neotropical	Reis TR 367
Eulacophyllum cultelliforme (Sull.) W.R. Buck & Ireland	CO	AM, AT, CA, SA, PL	Neotropical	Reis TR 381

North (AC, AM, AP, PA, RO, RR), Northeast (BA, CE, PE), Southeast (MG, RJ, SP), South (PR, SC).

Ceratolejeunea laetefusca (Austin) R.M.Schust., J. Elisha Mitchell Sci. Soc. 72 (2): 306. 1956.
The illustrations of this species is in Dauphin (2003).

It is characterized by the presence of caducous leaves and frequent reduced lobules. It was found on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC, AM, PA, RR), Northeast (BA, PE), Midwest (GO), Southeast (ES, MG, RJ, SP).

Cheilolejeunea acutangula (Nees) Grolle, J. Hattori Bot. Lab., 45: 173. 1979.
The illustrations of this species is in Gradstein & Costa (2003).

It is distinguished by clearly mammillose leaf cells and the presence of 2–5 oil bodies per cell. It was collected on rotting log. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AM, PA, RR), Northeast (AL, BA, PE), Southeast (ES, MG, RJ, SP), South (RS, SC).

Cheilolejeunea adnata (Kunze ex Lehm.) Grolle, J. Bryol. 9 (4): 529. 1977.
The illustrations of this species is in Grolle (1977).

It is characterized by leaf cells presenting trigones, lobules never reduced and with long apical and curved teeth, caducous leaves, and marginal rizhoids on leaves. It was found on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AM, PA), Northeast (BA, PE), Midwest (MT), South (PR, SC).

Cheilolejeunea discoidea (Lehm. & Lindenb.) R.M.Schust. & Kachroo, J. Linn. Soc., Bot. 56 (368): 509. 1961.
The illustrations of this species is in Bastos (2017).

It is distinguished by the small size of the gametophytes (up to 0.65 mm wide), being one of the smaller species of the genus. The reduced and weakly delimited trigones are also diagnostic characteristics. It was collected on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (PA), Northeast (BA, SE), Midwest (DF, GO, MS), Southeast (ES, MG, SP).

Cheilolejeunea xanthocarpa (Lehm. & Lindenb.) Malombe, Acta Bot. Hung. 51 (3-4): 326, 2009.
The illustrations of this species is in Gradstein & Costa (2003).

The striking features of this species are the leaf lobes with strongly involute margins. It was found growing on rotting log. This is the first occurrence for the Caatinga. Brazilian geographical distribution: Northeast (BA, CE), Southeast (ES, MG, SP).

Lejeunea aphanes Spruce, J. Bot. 19: 36. 1881.
The illustrations of this species is in Bastos & Yano (2004), as *L. filipes* Spruce.

The diagnostic feature of the species is the underleaf that grows attached to the stem and which is difficult to visualize due to its very thin cell walls which are usually collapsed. It was collected on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: Northeast (BA).

Lejeunea oligoclada Spruce, Bull. Soc. Bot. France 36 (Suppl. Congress Bot. 1889): cxcix. 1889 [1890].
The illustrations of this species is in Bastos & Yano (2009).

It may be confused with *Lejeunea phyllobola*; however, the smaller size of the gametophyte and the cells finely papillose in *Lejeunea oligoclada* distinguishes the two species. It was found on live bark. It is endemic to Brazil and this is the first occurrence for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: Northeast (AL, BA, PE), Southeast (ES, MG, RJ, SP), South (PR, SC).

Metzgeriaceae H. Klinggr.
Metzgeria albinea Spruce, Bull. Soc. Bot. France 36: 201. 1889.
The illustrations of this species is in Gradstein & Costa (2003).

It is characterized by the presence of two rows of cells on both surfaces (dorsal and ventral) of the midrib in transverse section, with about 10–15 medullary cells and two hairs per marginal cell. It was collected on live bark. This is the first record for the Caatinga Domain. Brazilian geographical distribution: Northeast (BA, CE, PE), Midwest (GO), Southeast (ES, MG, RJ, SP), South (PR, RS, SC).

Plagiochillaceae Müll. Frib. & Herzog
Plagiochila cristata (Sw.) Lindenb., Sp. Hepat. (fasc.1): 33. 1839.
The illustrations of this species is in Heinrichs (2002).

It is distinguished by leaves that are longer than wider, with 15 to 50 teeth, two long teeth at the apex, and dentate ventral margin. This is the first occurrence for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AM, PA), Northeast (BA, RN), Southeast (ES, MG, RJ, SP).

Plagiochila patula (Sw.) Lindenb., Sp. Hepat. (fasc.1): 21. 1839.
The illustrations of this species is in Gradstein & Costa (2003).

The dichotomous branching pattern, weakly dentate leaves with a high shoulder and with long-decurrent and entire ventral base are diagnostic characteristics of the species. Heinrichs *et al.* (1998) also mention the presence of a high dorsal wing in the perianth. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC, PA), Northeast (BA, PE), Southeast (MG, RJ, SP), South (PR).

Ricciaceae Rchb.
Riccia albopunctata Jovet-Ast, Cryptog. Bryol. Lichénol. 12 (3): 237, 1991.
The illustrations of this species is in Jovet-Ast (1991).

It is characterized by the numerous white spots, which are idioblastic cells visible through the epidermis, densely areolated distal spore surface and with tuberculated angles. It was collected on soil. This is the first citation for the state of Ceará. Brazilian geographical distribution: Northeast (BA), Midwest (MS, MT), Southeast (SP), South (PR, RS, SC).

Riccia subplana Steph., Symb. Antill. (Urban) 3 (2): 275, 1902.
The illustrations of this species is in Ayub *et al.* (2014).

It is characterized by stems 6–7 mm long, round apex, entire margin, absence of papillae or cilia, and presence of pink scales. It was collected on soil. The species has a disjunct distribution and had been recorded only for the Amazon forest and Rio Grande do Sul in Brazil (Ayub *et al.* 2014). It was found on soil. This is the first citation for the Northeast region of Brazil and for the Caatinga Domain. Brazilian geographical distribution: North (AM), South (RS).

Bryophyta
Bryaceae Schwägr.
Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac., Bryol. Jav. 1: 139, 1860.
The illustrations of this species is in Sharp *et al.* (1994).

It is distinguished by the ligulate-lanceolate leaves, equally arranged in the stem, with acute to acuminate apex, rhomboid-hexagonal cells, entire and bordered margins, and long-excurrent costa ending in a wing tip. It was found on soil. It is endemic to Brazil and this is the first record for the state of Ceará. Brazilian geographical distribution: Northeast (BA, PE), Midwest (GO, MS), Southeast (RJ, SP).

Rosulabryum densifolium (Brid.) Ochyra, Biodivers. Poland 3: 162. 2003.
The illustrations of this species is in Ochyra *et al.* (2003).

It is characterized by the robust size of the gametophytes, up to 10 cm long, narrow leaves, 6.5 mm long, with serrate margins. It was found on soil. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: Northeast (BA, PE), Midwest (DF), Southeast (ES, MG, RJ, SP), South (PR, RS, SC).

Calymperaceae Kindb.
Syrrhopodon parasiticus (Sw. ex Brid.) Besch., Ann. Sci. Nat., Bot., Ser. 8, 1 (5-6): 298, 1895.
The illustrations of this species is in Sharp *et al.* (1994).

It is characterized by dimorphic leaves with unipapillose cells, filamentous propagules in the median region of the leaf, and cancellinae ending in acute angles. It was collected on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC, AM, PA, RO, RR), Northeast (BA, PE), Midwest (DF, GO, MS, MT), Southeast (ES, MG, RJ, SP), South (PR, SC).

Fissidentaceae Schimp.
Fissidens perfalcatus Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 Afd. 3 (7): 13. 1900.
The illustrations of this species is in Sharp *et al.* (1994).

It is characterized by oblong-ovate leaves, with vaginant laminae completely covering the stem, usually extending beyond the stem, limbidium occupying all the extension or up to 3/4 of the vaginant lamina in all leaves, and unipapillose cells. It was collected on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (TO), Northeast (BA, PB, PE), Midwest (GO, MT), Southeast (ES).

Meteoriaceae Kindb.

Meteorium nigrescens (Sw. *ex* Hedw.) Dozy & Molk., Musc. Frond. Ined. Archip. Ind. 5: 160, 1848.

The illustrations of this species is in Buck (1998).

It is distinguished by gametophytes with cylindrical branches and blackish apex, weakly concave and triangular-ovate leaves, with gradually acuminate and never piliferous apex, cordate base, crenulated margin, costa extending up to 1/2 of the leaf, and sub-quadratic and smooth alar cells. It was found on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (PA), Northeast (BA, PE), Midwest (DF, GO, MS), Southeast (ES, MG, RJ, SP), South (PR, RS, SC).

Orthotrichaceae Arn.

Groutiella tomentosa (Hornsch.) Wijk & Margad., Taxon 9 (2): 51, 1960.

The illustrations of this species is in Sharp *et al.* (1994).

It is characterized by leaves with fragile and brittle apex, and marginal elongated basal cells contrasting with the rounded hexagonal cells of the lamina. It was found on live bark. This is the first record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AM, PA, RO), Northeast (BA, PE, SE), Midwest (MT), Southeast (RJ, SP).

Schlotheimia jamesonii (Arn.) Brid., Bryol. Univ. 1: 742. 1826.

The illustrations of this species is in Allen (2002).

It is distinguished by the glossy, green to brown coloration, densely tomentose gametophytes, oblong and smooth leaves with abruptly acuminate apex. It was found on rock. This is a new record for the Caatinga Domain and for the state of Ceará. Brazilian geographical distribution: North (AC), Northeast (BA, MA, PE), Midwest (DF, GO, MS), Southeast (ES, MG, RJ, SP), South (PR, RS, SC).

Pottiaceae Schimp.

Barbula indica (Hook.) Spreng., Nomencl. Bot. 2: 72. 1824.

The illustrations of this species is in Sharp *et al.* (1994)

It is characterized by elliptic ovate leaves with flat or weakly curved margins in the medial portion, presence of masses of green, ovoid propagules, with three or more cells, produced in the axils of the leaves. It was found on rock. This is the first record for the state of Ceará. Brazilian geographical distribution: North (AC, AM, PA), Northeast (BA, PE, RN, SE), Midwest (DF, GO, MS, MT), Southeast (ES, MG, RJ, SP), South (PR, RS).

Weisiopsis bahiensis (Müll. Hal.) Broth., Nat. Pflanzenfam. 10: 271. 1924. Fig. 2

It is characterized by small gametophytes, tubular leaves with flat to curved margins, flattened guide cells, absent or single peristome. It was found on rock. It is endemic to Brazil and this is the first report for the state of Ceará. Brazilian geographical distribution: Northeast (BA, PI).

Sematophyllaceae Broth.

Sematophyllum adnatum (Michx.) E. Britton, Bryologist 5: 65, 1902.

The illustrations of this species is in Buck (1998).

Gametophytes with erect-patent, ecostate, flat stem leaves, with gradually acuminate apex, weakly inflated and yellow-orange alar cells, quadrate supra alar cells, few in number (2–3), measuring 1/2 of the length of the alar cells. It was collected on live logs. This is the first occurrence for the state of Ceará. Brazilian geographical distribution: North (AM, PA, TO), Northeast (BA, MA, RN), Midwest (DF, GO, MS, MT), Southeast (ES, MG, RJ, SP).

Discussion

The 59 bryophyte species found in the Apodi Plateau correspond to 30% of the total number species registered in the state of Ceará. This number can be considered high when compared to other surveys carried out in Caatinga areas, such as those where were conducted the studies by Porto *et al.* (1994) in Caruaru county, where 17 species were registered, and Porto & Bezerra (1996), who reported 13 bryophyte species for the municipality of Agrestina, also in Pernambuco.

Among the liverworts, the most representative families were Lejeuneaceae (12 spp.) and Plagiochilaceae (4 spp.). As for mosses, the

families with the highest number of species were Bryaceae and Pottiaceae (4 spp.). In the present study, it was observed that the majority of the most frequent species have adaptations to thrive in restrictive environmental conditions, such as xeric environments, being considered generalists or typically adapted to solar incidence, such as *Frullania caulisequa* (Nees) Nees, *Riccia vitallii* Jovet-Ast, *Bryum argenteum* Broth., *Octoblepharum albidum* Hedw., *Campylopus savannarum* (Müll. Hal.) Mitt. and *Hyophilla involuta* (Hook.) A. Jaeger (Ochi 1980; Frahm 1991; Gradstein *et al.* 2001). As regards the family Lejeuneaceae, this is one of the largest families of liverworts and, although better represented in humid forests, they occur also quite frequently in open and xeric environments (Gradstein 1994; Gradstein *et al.* 2001). The Lejeuneaceae species recorded in this study present a considerable wide tolerance or are pioneers. In Brazil, they have also been found in disturbed forests, savannas, sandbanks, Caatinga and even plantations and pastures (Gradstein & Costa 2003; Forzza *et al.* 2010).

The results of this study reinforce the importance of the Apodi Plateau for the preservation of bryophyte species in Caatinga areas and for the recognition of hot spots in order to guide conservation efforts to areas with high diversity of species and endemism (Kier *et al.* 2009). According to Costa & Peralta (2015), Brazil has 242 endemic bryophyte species, of which only one is cited for the state of Ceará. The present study report three new records of endemic Brazilian species for the state

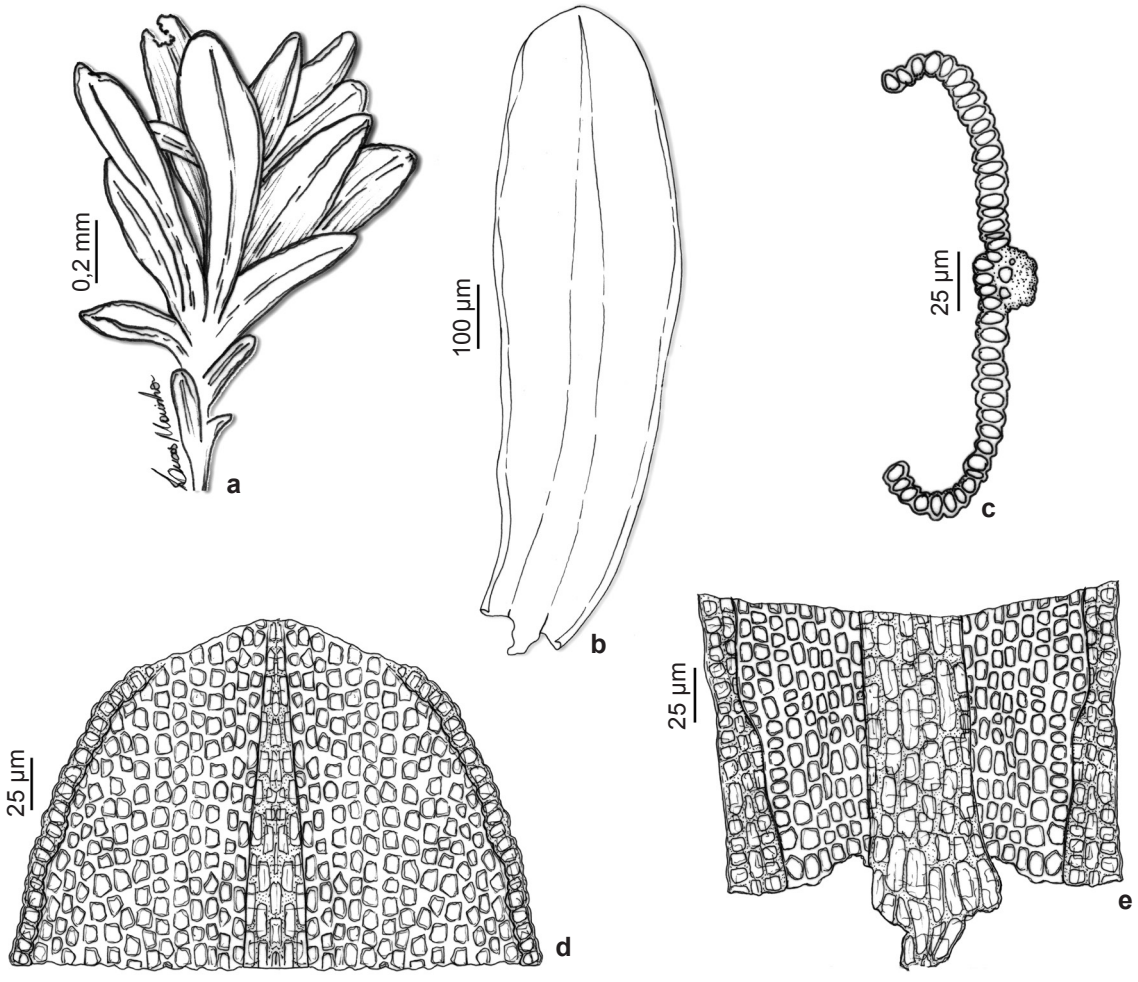

Figure 2 – a-e. *Weisiopsis bahiensis* – a. gametophyte; b. leaf; c. cross section of the leaf; d. leaf apex; e. basal portion of the leaf.

of Ceará: *Weisiopsis bahiensis* (Müll. Hal.) Broth., *Lejeunea oligoclada* Spruce and *Brachymenium exile* (Dozy & Molk.) Bosch & Sande Lac., the first two are also new records for the Caatinga Domain.

Weisiopsis bahiensis seems to have some inconsistencies in the information available in literature. According to the original work (Müller 1855, as *Pottia bahiensis* Müll. Hal.) The species type is from the state of Bahia, however, at the BFG (2018) platform, it is cited only for the state of Piauí, which is probably wrong. Yano *et al*. (2009) cited *W. bahiensis* from Oeiras, Goiás state, although Oeiras is actually located in Piauí state. Crosby *et al*. (1999) ranked it as a species for which no new information could be found in the post-1962 literature, however, Gradstein *et al*. (2001) considered this species as valid. Costa (2016) is the most recent citation of this species in Brazil, however, as well as Yano *et al*. (2009), with herbarium samples collected in 1978. Therefore, this work represents a rediscovery of *W. bahiensis* in nature and the third record in Brazil and in the world.

The high number of new species reported for the state of Ceará and for the Caatinga Domain underscores the importance of continuous floristic surveys, especially in areas to which there is a gap of knowledge such as the Apodi Plateau, part of the Caatinga Domain in the Semiarid region of Brazil.

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